

# A Comparison of Manual Soil Preparation with the Fritsch P-8 Soil Mill



Figure 1. The Fritsch P-8 Soil Mill is used to process soil samples for analyses at the Soil Survey Laboratory.



Figure 2. Manual preparation of soils for analyses at the Soil Survey Laboratory.



Figure 3. Soil samples prepared for analyses are stored in one-half pint cartons.



Figure 4. A view of the brushes used to gently crush soil samples and discharge rock fragments.



Figure 5. Loading the Fritsch P-8 Soil Mill with sample for processing.

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## Abstract

The Soil Survey Laboratory implemented the use of a Fritsch P-8 Soil Mill (P-8 Mill) to replace some of the manual soil sample preparation. Preparation time was reduced from about 30 minutes to 10 minutes per sample for clayey soils with coarse fragments (>2 mm), while the preparation time was reduced from 10 minutes to 7 minutes for medium-textured soils with no coarse fragments. Data indicate no significant difference for sand and silt content from particle size analysis using the two methods; however, there was a significant difference in clay ( $\alpha = .05$ ) between samples prepared manually from those prepared using the P-8 Mill. Samples with pararock fragments were judged unsuited for preparation using the P-8 mill. Advantages of using the Fritsch P-8 Mill include reduced processing time and reduced need for manual labor. Disadvantages include possible contamination among samples, loss of clay, and limited use for samples with pararock fragments.

## Introduction

The use of the P-8 Mill (Figure 1) has been an effective tool for use in the Sample Processing Section of the National Soil Survey Laboratory (SSL). It is a machine designed for processing whole soil to <2 mm size while removing and storing the >2 mm fraction in a separate holding container.

Traditionally, sample preparation has been a manual process at the Soil Survey Laboratory (Figures 2 and 3). It has been a challenge to find people who are willing to spend time on a consistent basis manually grinding soil samples. Additionally, budget constraints have forced the SSL to look for alternative methods to reduce labor cost. The P-8 Mill has allowed us to partially meet our need of finding a machine that will reduce the manual labor needs and speed up the processing of soil samples (Table 1). However, it is more efficient to process soils by hand in some instances depending on various factors such as texture of soil, size of soil sample to be processed, and the amount of >2 mm fraction in the sample. The overriding factor for determining whether to process a sample by hand or with the P-8 Mill, especially with smaller samples, is the amount of time required for cleanup of the mill between samples. The objective of this study was to test the effectiveness of the P-8 Mill as a tool for sample preparation.

## Results and Discussion

Soils from a variety of textures, geological settings, and with varying amounts of coarse fragments were prepared for standard characterization analysis according to the Soil Survey Laboratory Manual (Soil Survey Laboratory Staff, 1996). Duplicate samples were prepared using the P-8 Mill. Data suggest (Figures 6, 7, and 8; Table 2) that there was no significant difference between samples prepared with the P-8 Mill and those prepared by standard preparation for sand and silt from particle size analysis. However, there was significantly less clay-size fractions, which was attributed to a failure to break down clay aggregates in the sand and silt-size fractions using the P-8 Mill sample preparation. The standard preparation of soils for characterization (Figures 2 and 3) involves mostly manual crushing of soil samples using a wooden rolling pin and the sieving of rock fragments >2 mm (Soil Survey Laboratory Staff, 1996).

The P-8 Mill crushes soils by the combined force of impact and friction. Rotating spiral nylon brushes are attached to a cylinder inside of a chamber where the sample is gently crushed, while it is simultaneously conveyed along a perforated plate that has 2 mm holes within the chamber (Figures 4 and 5). The processed sample is collected in a container at the base of the mill, while the coarse fractions are retained and finally separated at the end of the grinding chamber and collected in a pan. The whole process is essentially dust-free, except for the cleaning of the mill between samples where dust particles may be trapped between the nylon brushes.

The amount of soil sample received for processing varies as does the texture, parent material, and the amount and density of coarse fragments. A standard sample for characterization analysis usually weighs about 4,500 grams (about the capacity of the pan in the P-8 Mill). If the sample is significantly smaller than a standard sample, it may be more efficient to prepare manually rather than using the P-8 Mill because of the cleanup time.

Soil texture was a major factor of consideration when using the P-8 Mill. Soils with clayey textures take longer to manually process than does processing with the P-8 Mill, especially if the samples contain coarse fractions (Table 1). Using the P-8 Mill, processing a clayey sample and cleanup of the mill takes less than 15 minutes, which reduces the processing time by one half (Table 3). One disadvantage of the P-8 Mill is that when a soil is clayey, clay balls may not be completely crushed and are collected with the coarse fragments (Table 4). These clay balls must then be hand-processed and remixed with the sample. Even so, this process was faster than the standard manual processing. Medium-textured soils with coarse fractions were efficiently processed by the P-8 Mill. Coarse-textured soils (sandy soils) were usually more efficiently processed by hand when the cleanup time is considered. Organic soils were not practical to process with the P-8 Mill because the organic fibers clogged the sieve plate.

If soils had grus-type materials (pararock), it was necessary to hand-crush the sample because of the need to use human judgement in separating rock fragments from soil. Even though the nylon brushes were considered gentle, it was our judgement that some soft rock destruction occurred.

## Summary and Conclusions

- ❖ Use of the P-8 Mill in sample preparation reduced the overall preparation time for most samples.
- ❖ Sandy samples can be prepared as fast manually as by using the P-8 Mill.
- ❖ Soils with soft rock fragments (pararock) are not suited for processing with the P-8 Mill because of the need for judgement in separating rock from soil.
- ❖ One of the major factors in considering the use of the P-8 Mill is the nearly 5-minute cleanup time between samples.
- ❖ It is also recommended that the P-8 Mill be used in a well-vented area to reduce the dust during cleaning.
- ❖ Because samples prepared using the P-8 Mill are ground more uniform than they are during conventional preparation, the analysts felt that the time needed to fine grind samples (<80 mesh) for analyses such as total carbon and total nitrogen is reduced.
- ❖ The P-8 Mill is a valuable instrument for the SSL because it provides for more efficient processing of most soil samples, thereby saving time and money.
- ❖ There is a need for a more efficient and effective way of cleaning the P-8 Mill between samples.

- ❖ There is a need for further testing of the P-8 Mill to determine how we may reduce the loss of clay using this method.

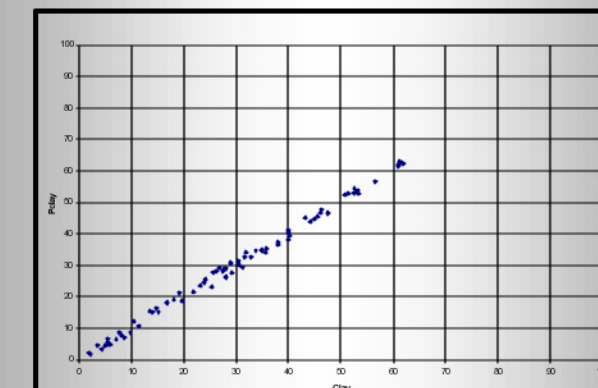


Figure 6. A plot of clay from particle size analysis using the Fritsch P-8 Soil Mill (Clay) and manual preparation (Pclay).

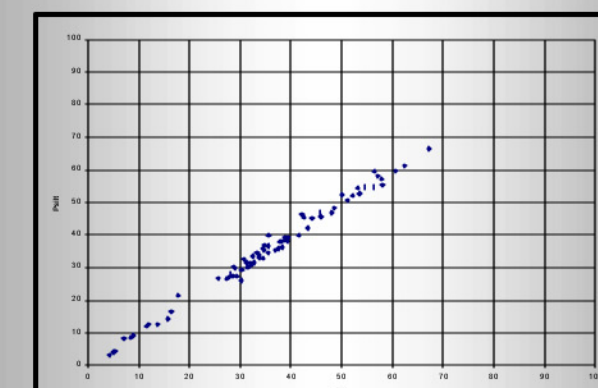


Figure 7. A plot of silt from particle size analysis using the Fritsch P-8 Soil Mill (Silt) and manual preparation (Psilt).

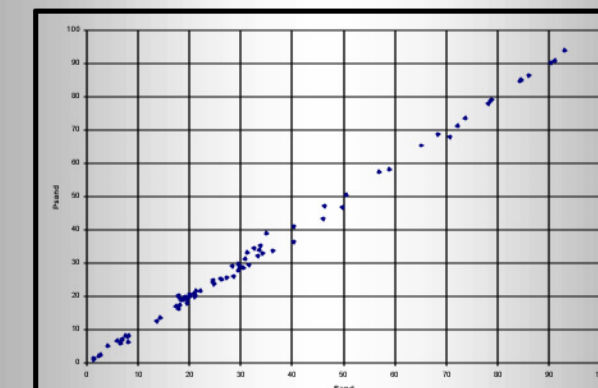


Figure 8. A plot of sand from particle size analysis using the Fritsch P-8 Soil Mill (Sand) and manual preparation (Psand).



Figure 9. The Retsch Cross-Beater Mill used to process organic soil samples.

## References

Soil Survey Laboratory Staff. 1996. Soil Survey Laboratory Methods Manual, Soil Survey Investigation Report No. 42, Version 3.0. U.S. Gov. Printing Office, Washington, DC. Page 693.

Fritsch P-8 is a trade name for the "Soil Deagglomerator Pulverisette 8", Fritsch GmbH, Industriestrasse 8-D-55743 Idar-Oberstein, Germany. Use of the instrument in this study does not indicate an endorsement for this product.

Table 1. Estimated Time for Sample Preparation Using a Fritsch P-8 Mill and Manual Preparations.

Soil Texture	P-8	Manual
Sandy	7 min	3 min
Loamy	7 min	10 min
Clayey	10 min	15 min
Clayey-Skeletal	10 min	30-40 min
Organic	N/A	10 min*

\* Manual preparation includes use of the Retsch Cross-Beater Mill (Figure 9), Retsch GmbH & Company, Haan, Germany.

Table 2. T-test for Paired Two Sample Means Using a P-8 Mill and Manual Preparations.

	sand	psand	silt	psilt	clay	pclay
Mean	33.60385	33.42051	35.62564	35.49359	30.77051	31.0859
Variance	634.2562	636.3105	210.4721	212.7497	316.4655	323.7519
Observations	78	78	78	78	78	78
Pearson Correlation	0.998766		0.994721		0.998023	
Hypothesized Mean Difference	0		0		0	
df	77		77		77	
t Stat	1.292236		0.779163		-2.43614	
P(T<=t) one-tail	0.10007		0.219136		0.008578	
t Critical one-tail	1.664885		1.664885		1.664885	
P(T<=t) two-tail	0.20014		0.438272		0.017156	
t Critical two-tail	1.991257		1.991257		1.991257	

Table 3. Advantages of the Fritsch P-8 Soil Mill.

- ❖ Saves time in preparation of most samples.
- ❖ Works well with large samples (1000-4500g).
- ❖ Processes samples with coarse fragments easily.
- ❖ Saves on labor expenditures.
- ❖ Instrument is self-contained with safety features.
- ❖ Unit is mostly maintenance free except for brushes.
- ❖ Reduces fatigue in workers.

Table 4. Disadvantages of Using the Fritsch P-8 Soil Mill.

- ❖ Requires cleaning between samples (about 5 min).
- ❖ Brushes (nylon) require replacement.
- ❖ Creates excess dust during cleaning.
- ❖ Possible cross-contamination of samples at micro-levels.
- ❖ Not suited for small samples or organic soils.
- ❖ Not suited for soft rock because of possible destruction.
- ❖ Some clay loss during preparation.